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Building a Smart City: Insights and Perspectives from the Winners of Smart City Challenge

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Geographical keywords: Canada, Ontario, Quebec, Nova Scotia, Nunavut, Montreal, Bridgewater, Guelph, Wellington.

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Abstract

When Canadian Government launched smart city initiative over 130 municipalities, large and small have submitted their innovative ideas. On May 14, 2019, the four winners of the Canadian Smart Cities Challenge were announced in Ottawa: Town of Bridgewater, Nova Scotia winning $5M Prize Category; the Nunavut Communities, Nunavut winning $10M Prize Category; the City of Guelph and Wellington County, Ontario winning $10M Prize Category and the City of Montréal, Quebec winning $50M Prize Category.

This paper focuses on these four cities by exploring two main research questions: (1) what does “smart cities” mean for Canadian municipalities; and, (2) what are the elements of smart city initiatives in Canada? This paper aims to build an understanding of smart city initiatives in Canadian context and explore what smart city means for Canadian municipalities.

Based on previous research, the main areas explored in this research are categorized in eight aspects including (1) technology, (2) management and organization, (3) policy context, (4) governance, (5) people and communities, (6) economy, (7) built infrastructure and (8) natural environment.

Geographical Areas

Canada, Ontario, Quebec, Nova Scotia, Nunavut, Montreal, Bridgewater, Guelph, Wellington

Subject keywords: City Government, Policymaking, Innovation, Technology, Management, Collaboration,

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1. Introduction

Urbanization is an increasing phenomenon across the globe. More and more people are gravitating towards urban areas. More than half of the world's population currently lives in urban areas and this is going to increase to 66 percent by 2050 (World Urbanization Prospects, UN, 2014). The urban population has grown rapidly from 746 million in 1950 to 3.9 billion in 2014 and it is expected to surpass six billion by 2045 (ibid). This indeed brings a number of new opportunities because urban areas have historically been linked to better educational and health opportunities, a nurturing space for cultural and political activity with increased economic and development activity. However, rapid and unplanned urban growth carries with it a number of problems such as pollution, environmental degradation, and unsustainable development.

To prevent and overcome these challenges, governments are required to think outside the box and come up with solutions that are complex and require the intervention of an innovative government. Too often, these complexity of innovation within government is labeled as smart city initiatives which seek solutions to specific urban management challenges by using new innovative technologies.

The smart cities initiatives are becoming a primary intervention method to urban challenges and governments across the globe have spent about $80 billion in 2016 in smart city technology solutions. This figure is expected to grow to $135 billion by 2021 (Shirer, 2018).

Governments in the European Union are being supported by the European Union to increase the number of smart cities to 300 by the end of 2019 (Taylor, Ke-Tai, Sheng, Yi & Guan-Hong, 2018). The major European smart cities initiative is carried under the umbrella of the European Innovation Partnership on Smart Cities and Communities. This initiative is intended to serve as a framework for EU smart initiatives aiming to enable European cities to emerge strengthened from the recent financial and economic crisis (European Commission, 2013).

Governments in Asia are also taking lead in enabling smart cities initiatives. India has launched a US$14 billion initiative aiming to develop 100 cities across the country making them citizen friendly and sustainable (Indo-Canada Chamber of Commerce's ICCC, 2016).

In North America, United States, about 66% of cities are already investing in smart city technologies and in 2016 the Obama Administration announced $80 million investments in Smart Cities Initiatives. These initiatives are focused on improving transportation, public safety, addressing climate change and other city services. Also, Canada, is one of the countries with the highest concentrations of population in large and medium-sized cities among G7 nations, has launched for the first time the Smart City Challenge, a Federal Government program. This challenge was launched in 2018 and it aims to empower municipalities and communities across Canada to address pressing local issues by using data and connected technology.

Acknowledging this prominence, this research paper aims to explain smart city initiatives in Canada in the light of Smart City Challenge in Canada. The paper will build an understanding of smart city initiatives in Canada through a case study of four winners of

Smart City Challenge—Montreal (QC), Nunavut, Guelph/Wellington (ON), and Town of Bridgewater (NS).

1.1 Research Questions

This paper will aim to answer two main research questions. First, what does “smart cities” mean for Canadian municipalities? Second, what are the elements of smart city initiatives in Canada?

The research will be carried in two domains: the first domain will provide an in-depth literature review which will highlight the academic discussion about the smart cities and the elements that make a city considered smart. This theoretical information is used to create a theoretical framework on key definitions and elements of smart city initiatives throughout the world

The second domain will include qualitative research that will explore how Canadian municipalities defines smart cities and what are its key agendas in the smart city realm. In the Canadian context, this paper will focus four selected successful applications in the Smart City Challenge in an attempt to explore how municipalities in Canada understand smart cities and what are the key elements included in their smart cities’ initiatives. It will also investigate how the policy context shaped Canadian smart city initiatives, and the role and influences of technology and management in shaping smart cities initiative in municipal level.

In addition, this paper will bring forward the impact these initiatives will have on people, local economies, environment and infrastructure.

The paper is structured accordingly. The next section provides an exhaustive and systematic literature review as an integrative framework to understand smart city initiatives. The subsequent section discusses the methodology of data collection and rational behind case selection. Then, the next section reports findings and analysis from the results. The last section presents concluding remarks and addresses future research.

2. Literature review

2.1 Definitions of Smart Cities

Smart city is a relatively new concept. In the past years, its prominence has increased substantially on a yearly basis. A library search using SCOPUS, an abstract and citation database of peer-reviewed literature, shows that between 1999 to 2011 there were merely 25 publications about smart cities. While, in 2018 alone, the number of publications on this topic was 1088 papers. China, USA and India were leading countries/territories with highest number of articles on smart cities; followed by the European Union countries such as Italy, United Kingdom and Spain. Canada is in the 12th place with overall 68 articles. This confirms that the smart city is a real movement which is growing exponentially in all continents.

The emergence of information and communication technologies (ICT) has significantly influenced the interaction and communication between individuals, governments, businesses. It has also enabled the emergence of the smart city concept. However, despite the frequent usage of Smart City as a term, there is a lack of consensus on a concrete definition (see Appendix I for definition list). The term was first used by the California Institute for Smart Communities in the 1990. With the emergence of new ICT

technologies, they were interested on how communities can become innovative and how a community can introduce data technology (Alawhadi et al., 2012).

As result, there is a number of definitions provided from different standpoints. Simultaneously, there is an overlap of terms used to describe the same phenomena such as smart city, digital city, intelligent city, information city, and innovative City. Some of these labels emphasize technological aspects as a driver or enabler, while others pay more attention to the development of human capital or physical infrastructure (Pardo et al, 2015). The paper has collected certain definitions from various sources to emphasize the uniform nature of the notion.

Several authors focus on the smart cities' infrastructure aspects. According to Hall et al. (2000:pg 1), a smart city is "a city that monitors and integrates conditions of all of its critical infrastructures, including roads, bridges, tunnels, rails, subways, airports, seaports, communications, water, power, even major buildings, can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens". The key features of this definition are the ability of the City to maximize its resources in modernizing its infrastructure and providing great service to its citizens. Similarly, Harrison et al. (2010: pg 2) defined the smart city as one that "connects the physical infrastructure, the IT infrastructure, the social infrastructure, and the business infrastructure to leverage the collective intelligence of the city". They speak about an intelligent city that has integrated its physical and information technology infrastructure to enable people and businesses to leverage opportunities for the betterment of life. Washburn et al. (2010) see smart cities as a collection of innovative technology processes to integrate and improve services. According to them, a smart city is: "the use of smart

computing technologies to make the critical infrastructure components and services of a city—which include city administration, education, healthcare, public safety, real estate, transportation, and utilities—more intelligent, interconnected, and efficient" (pg 2).

Mohanty et al. (2016) look at the ability of smart cities to leverage technologies to improve their traditional networks and services. They argue that a "smart city is a place where traditional networks and services are made more flexible, efficient, and sustainable with the use of information, digital and telecommunication technologies, to improve its operations for the benefit of its inhabitants. In other words, in order to better use the funds while having a smaller environmental impact, modern technology translates into good public services and for people (pg 60).

Since Information Technologies are not able to be effective without human factor, there is a collection of literature based on the role of human factor in enhancing urban development. Nijkamp et al. (2009) consider that investment in social capital, sustainable growth, and participatory governance are important features of smart cities. This group of authors argue that a city is considered smart "when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance" (pg 50). Giffinger et al. (2007) focus on the ability of the city to foster proactive actions that will lead to economic development, good governance, mobility and citizen engagement, He provide the following definition of the smart city: "A city well performing in a forward-looking way in economy, people, governance, mobility, environment, and living, built on the smart combination of endowments and activities of self-decisive, independent and aware citizens" (pg 708).

As mentioned earlier, governments and industry partners are continuously taking initiatives to support smart cities initiatives. They are doing so by providing funding and initiating competitions between local governments. As result, governments and industry partners provide their own definitions and elements of a smart city.

For example, IBM (2016), an industry leader in technology and communication which runs its own Smart Cities Challenge, defines the smart city as an organization that “know how to transform their systems and optimize use of largely finite resources and make their systems instrumented, interconnected and intelligent” (pg 1). This definition highlights the IBM shift in developing technologies that enables cities to use sensors, big data and system integration to run a smart city.

A set of definitions is also found in the government policies and initiatives enabling smart cities initiatives. The European Innovation Partnership on Smart Cities and Communities provides the following definition: “smart cities should be regarded as systems of people interacting with and using flows of energy, materials, services, and finance to catalyse sustainable economic development, resilience, and high quality of life; these flows and interactions become smart through making strategic use of information and communication infrastructure and services in a process of transparent urban planning and management that is responsive to the social and economic needs of society” (European Commission, 2013). For the Canadian Federal Government, a smart cities approach means “achieving meaningful outcomes for residents through the use of data and connected technology”.

Evidently, the variety of definitions and concepts make it hard to reach a common framework and consensus on the significance of the smart city as a concept. Except for

the component of ICT, these definitions are very diversified in their scope and understanding of the way smart cities function and the areas they effect.

2.2 Core components and dimensions of the smart city

An important discussion in the literature review is built around the core components and dimensions of the smart city. What elements make a city be considered “smart”? As provided in the above-mentioned definitions, there are certain characteristics that cities adopt in order to become smart in the way they conduct business.

Information technology and communication are considered an important dimension of smart cities however other dimensions are equally important. According to Zahi et al (2016) the city is really smart when the highlight is not just the technology, but also the people and the communities. According to this group of authors, three core dimensions are important: (1) technology, (2) people, and (3) community. On the other hand, Nam and Pardo (2011) identified four dimensions: (1) government, (2) society, (3) physical environment, and (4) technology and data.

Another group of authors, Neirotti et al. (2014), provides a more holistic approach towards of smart cities by presenting a taxonomy of domains. They present the into ‘hard’ and ‘soft’ domains and group key elements into six categories: (1) natural resources and energy; (2) transport and mobility; (3) buildings; (4) living; (5) government; (6) economy and people.

Based on the literature, Giffinger et al. (2007) proposed six comprehensive components which are widely used nowadays to measure smart cities (1) smart economy, (2) smart

people, (3) smart governance, (4) smart mobility, (5) smart environment, and (6) smart living.

According to IBM (2010: pg 1), operationally, cities have “six core systems composed of different networks, infrastructures and environments related to their key functions: people, business, transport, communication, water and energy”. In addition, a “people’s city” includes public safety, health and education in the core of their services. Each of this service has its own challenges and limited resources. A smart city seizes opportunities that new technologies offer to transform their core systems and optimize their limited resources.

3. Conceptual Framework

From the literature review provided, the smart city is defined in various ways in the literature of the city governance, initiatives of government agencies and private industry partners. To date, there is no general agreement for one definition over the other. However, the literature review reveals that cities define smart city initiatives based on their goals and the aims they are striving to achieve. For example, some cities define smart city initiatives as an ability to maximize their resources or use technology to integrate and improve services. As such, the definition of smart city initiatives is a good indication of the vision of the city or a particular area the city is endeavouring to excel.

In addition, the literature review reveals some common highlights about what elements are critical in a smart city initiative. Technology, people, community, management,

governance, environment, resources and infrastructure have been highlighted as important elements of a smart city initiative.

The Smart City Initiatives Integretive Framework created by Cheroubi (2012) et al to analyze smart city initiatives and used by Alawadhi S. et al. (2012) in North America, highlights eight components of smart city initiatives such as technology, policy context, management and organization, governance, economy, people and communities, natural environment and built infrastructure (Cheroubi et al., 2012). The framework shows how smart cities influence different dimensions but also vice versa. Technology, management and organisation, and policy context play a substantial role in the formation of smart city initiatives, but initiatives can also lead to changes in these three factors. The smart city initiative can lead to changes in regard to cities/municipality policy environment, technological capacities and management and organisation structure.

Their research also reveals important aspects to be considered when analyzing elements of the smart city initiatives by asking important questions that explore the nature of the initiative such as: when did the initiative start, what were the main goals and what organizations are involved in undertaking such initiative. These questions reveal the origin of these initiatives as well as the role of multiple actors involved.

Another set of questions explore the technological aspects of the smart city initiative by focusing on how these technologies are being used and what are the challenges of using such technologies. The questions related to management and organization aim to provide greater understanding of the management and organizational aspects of smart city initiatives, including how the initiative is managed, the nature of its organizational challenges, and challenges may be overcome. In the policy context, it aims to explore the

relationship between the initiative and the policy environment. The governance questions look at how these initiatives are governed, the authority and role of staff, partners, stakeholders and citizens are involved in these initiatives. The questions regarding people, community and economy explore how the smart city initiative affects the population and communities of the city and the economy. Lastly, the built infrastructure and natural environment explore the relationship between the initiative and the built infrastructure such as roads, bridges, power grid, water systems and the relationship with the city's natural environment. Table 1 lists the above-mentioned questions which will also be addressed in this study.

These key questions exploring various aspects of the smart city initiatives are particularly relevant in addressing the specific research questions about the definition and elements of smart city initiatives in Canadian context.

Nam and Prado (2011) offer a similar comprehensive view of smart city initiatives based on technology, management, and policy innovations. As a variety of definitions suggested, technology is considered a core component and driver of a smart city. When applied to critical infrastructure, they provide possibilities for improving city management and functionality. Despite improving business processes and quality of services, they can also create several challenges. Notably, the lack of IT skills and (cross-) organizational (cultural and political) challenges need to be addressed. This requires proper management and policy innovation where cities need to create capacity to manage and organize technology efficiently and must tackle institutional and non-technical urban issues to create positive urban development conditions.

In this regard, local management should take into account considerations regarding resource accessibility, capacity, organizational readiness and change, digital divide and culture.

Thus, the smart city initiative can be seen as a contextual and complex interaction around technology innovation and management and as the organizations that foster administrative innovation and political innovation.

This conceptual framework offers a crucial framework in assessing the scope of smart cities and for studying initiatives of smart cities. It provides a good context for assessing how municipalities in Canada have approached their smart initiatives, implement its project and address it challenges. It also proposes a selection of factors which will help in predicting respective successes of the smart city initiatives.

Table 1. Questions Rubric

Components	Questions
Technology	What technologies are being used and what are the implications of using such technologies?
Management and organisation	How is the initiative managed, the nature of its organizational challenges, and challenges may be overcome?
Policy Context	What is the relationship between the initiative and the policy environment?
Governance	How does the smart city initiative affect governance?
People and Community	How does the smart city initiative affect the population and communities?
Economy	What is the impact of the smart city initiative in the local economic development?
Natural Environment	How does the smart city initiative affect Natural environment?
Infrastructure	How does the smart city initiative affect Infrastructure?

4. Research Methodology

This paper focuses on the four cities that were successful in the last competition of the Smart Cities Initiative sponsored by Federal Government of Canada: Nunavut Communities (Nunavut), Montreal (Quebec), Bridgewater (Nova Scotia), and Guelph/Wellington (Ontario). These cities are located in three different provinces and one territory. In addition, they are quite different in terms of their position within their province or territory, number of inhabitants, economy and surrounding environment. The selection of these cities for this qualitative case study research was done purposely because they are winners in the recent Smart City Challenge in Canada. These winners were announced on May 14, 2019 in Ottawa with the Town of Bridgewater, Nova Scotia winning $5M Prize Category; the Nunavut Communities, Nunavut winning $10M Prize Category; the City of Guelph and Wellington County, Ontario winning $10M Prize Category and the City of Montréal, Quebec winning $50M Prize Category. The four selected cases provide a great composition of multiple jurisdictions in Canada and a mixture of small and large municipalities involved in this study.

The primary data for this qualitative research are the applications these cities submitted in the Smart City Challenge competition. These documents are publicly accessible on the Smart City Challenge web page. Additional research was conducted to understand the factors that characterized these smart city initiatives. As such, the municipal council meeting minutes were accessed to explore the policy environment and the relationship between actors involved in the development of these smart city initiatives.

As provided in the conceptual framework, the first set of questions in this research will focus on factors that help shaped the smart city initiative in four municipalities. The second set of questions will explore the potential impacts of smart city initiatives. This will be done by using the eight components of smart city initiatives highlighted in by Cheroubi. et al. (2012) study of smart city initiatives. As such, the key findings will be categorized in eight components as (1) technology, (2) management and organization, (3) policy context, (4) governance, (5) people and communities, (6) economy, (7) built infrastructure and (8) natural environment.

Due to time and resource constrains, this study is unable to bring perspectives of actors involved in these initiatives. Therefore, future research may focus on investigating and observing the actors involved in these initiatives to enrich the understanding of what smart city initiatives means and what elements of the smart city are important to Canadian municipalities.

3.3. An overview of the selected cities

This section summarizes the four successful smart city proposals.

3.3.1 Montreal, Quebec

Montreal is the recipient of $50 million the biggest prize of Smart City Challenge. The funding will be put towards its smart city plan to improve the well-being of residents of Montreal through mobility and food access. This smart city initiative was shaped through a thorough consultation with residents of Montreal who have strongly agreed that mobility followed by access to local services is the main issue in their city.

The project will use technology and data to offer its citizens access to local services by bringing new and improved public transport initiatives (car sharing on-demand, autonomous vehicles, bike sharing etc.) which will reduce car dependency and, improve access to sources of food. In addition to technology, the project will be dependent on a collective decision-making mechanism. A collaborative and inclusive governance model will be created to guarantee a safe and accountable technology implementation, thereby preventing abuse with personal data and information.

This initiative is aligned with the Montreal 2014-2017, Smart and Digital City Strategy and Provincial plans, particularly, the lately introduced Sustainable Mobility Policy 2030. This strategy demonstrates the government of Quebec's willingness to speed up the transition towards viable transportation, setting optimistic targets including 20 percent reduction in riding alone, 30 percent increase in public transit and 20 percent reduction in transport costs for families.

3.3.2 Guelph/Wellington, Ontario

The City of Guelph will use the $10 million prize to leverage its unique position and agricultural capacities. In collaboration with the Wellington County, this initiative aims to build a food community of the future, where there is less waste and more nutritious and healthy food. The main goal of this initiative is to transform and bring balance to Guelph and Wellington food system and community and enable them to live a healthy lifestyle. Their vision points toward remodelling the production, distribution and consumption into circular food economy.

To achieve this, they have set three goals. The first goal is to increase access to affordable, nutritious food by 50 per cent by re-imagining a smart food system to ensure food security and healthier outcomes.

The second goal aims to form 50 new circular business and collaborations by 2025. They plan to organize people from different backgrounds with diverse expertise, talent and resources. In addition, they plan to use data, latest technology and innovation to solve food system challenges and create new circular businesses, job opportunities and social enterprises. They will also organize training opportunities to prepare local people to work in the new food economy.

The third goal is to increase circular economic revenue up to 50% until 2025 by recognizing the value of waste. Their initiative is to re-imagine, re-use and revalue the food ecosystem by reducing negative environmental effects.

This project aligns with Guelph focus on the agri-food sector. In the City of Guelph's economic development strategy Prosperity 2020, Agriculture, Forestry, Fishing and Hunting is identified as an emerging industry with one of the highest percentage employment growth. This requires the City’s broad networks such as community partners, business, government and the university to seek out innovative solutions to community challenges and support the local and regional economy.

3.3.3. Bridgewater, Nova Scotia

Energy poverty is a growing problem in Bridgewater, affecting the wellbeing of residents. The high cost of power bills, inability to afford transportation needs and the burden of energy insecurity have affected the residents on meeting their basic needs. It is estimated

that 40 per cent of residents experience some form of 'energy poverty'. The $5 million prize will enable Bridgewater to lift 20% of its residents out of energy poverty by 2028. The funding will cover a portion of the $90 million needed to help vulnerable communities meet their energy needs in the next century.

With the help of data platforms and connected technology, the town will reduce the effects of energy poverty in the community through implementing clean energy initiatives. There are a number of activities that the initiative will undertake. The first is the installation of sophisticated energy monitoring and communications equipment in over 1,000 low-income homes. The second direction is developing a financial program that will use real-time energy information which will calculate the opportunities in financial investment for energy improvements. The third is improvement of its transportation systems and increasing local clean technology sector training and literacy.

The project supports community's medium and long-term goals Energy sustainability, security, and affordable energy have been core objectives Integrated Community Sustainability Plan (ICSP, 2010). The implementation of the project requires a collaboration framework. Bridgewater have identified partners that can contribute to the development and implementation of the initiative. Some of the stakeholders in the initiative will include community, environmental non-government organization, technology firms, university, fuel company and energy networks. They will play a huge role in the program by increase their capacity to exchange knowledge and work more efficiently and effectively to reduce, and ultimately end, energy poverty in Bridgewater.

3.3.4. Nunavut Communities, Nunavut

The Nunavut communities initiative is the winner of $10 million prize. The purpose of the initiative is to promote positive Mental Health by focusing on implementing and increasing protective factors and preventative measures to reduce the risk of suicide.

The suicide prevention approach is the creation of locations for the community to learn, increasing peer support, accessibility to educational resources and creation of channels that will encourage positive Mental Health. The purpose is initiative is to connect the community with both physical and digital spaces/platform, so they can share knowledge, and have access to tools, resources and support and life-promoting activities. Nunavut is building hubs for digital activities and educational resources with the goal of setting networks for youth where they can build and learn new skills.

The initiative, titled Community, Connectivity and Digital Access for Suicide Prevention in Nunavut, will be implemented by a wide range of network that will play an essential role in the execution of the project. Key stakeholders are the regional associations that manage lands and service organizations who will provide social services to youth. Collaborations with other partners like education institutions, health, cultural organizations etc. and private sector funders which will support the communities to implement the life promotional approach to prevent suicide.

5. Discussion and Analysis of Selected Cases

As provided in the analytical framework, this section will explore how municipalities understand smart cities and what are the key elements included in their smart cities' initiatives. The focus of discussion and analysis will be four selected successful applications in the Smart City Challenge. Table 1 contains an outline of the focus areas and the technological implications of the smart city initiatives included in the study.

Table 2: Focus areas and technical implications

Cities	**Smart city Initiatives**	**Focus area**	**Technologies implicated**
Montreal	Innovating in mobility: 1) Promote user autonomy and facilitate mobility with a new open digital platform 2) enhance the overall Integrated Mobility solution by facilitating short distance travel within neighbourhoods and by offering local mobility solutions adapted to the specific realities of different urban clusters. Food innovation: share infrastructure and resources for local production, distribution, storage and food processing (City of Montreal, 2019)	Mobility, Empowerment and inclusion	Networks (5G), Internet of Things (IoT), data sharing, blockchain
Nunavut	Increase the amount and accessibility of peer support networks, educational resources and creative outlets that promote positive Mental health to all Nunavummiut,	Empowerment and inclusion, Healthy living and recreation	Networks, Mobile applications
Guelph/Wellington	By 2025, Guelph and Wellington will become Canada's first data and technology enabled circular food economy by 1)Ensuring food security and healthy outcomes by making affordable, nutritious, local food 50% more accessible. 2)Creating new opportunities with 50 new circular businesses and collaborations 3)Creating new opportunities and sources of revenue by valuing waste as a resource, resulting in a 50% increase in circular revenue across diverse community	Economic opportunity Empowerment and inclusion Environmental Quality	Big data analytics, Cloud computing, Sensors, Video analytics, Internet of Things (IoT), Mobile applications, Networks, Open data platforms, Environmental monitoring, Geospatial,
Town of Bridgewater	Bridgewater will install sophisticated energy monitoring and communications equipment in over 1000 low-income homes, develop a self-funding energy retrofit financing program, improve its transportation systems, and increase local clean tech sector training and literacy.	Empowerment and Inclusion, Environmental quality,	Internet of Things (IoT), Sensors, Cloud Computing, Environmental monitoring's, Networks, Big Data Analytics.

4.1 Technology

Technology is a very important part of the smart city initiatives. The meaning of technology is broad, encompassing all forms of technology that involves any form of tools and machines that may be used to solve real-world problems. In the concept of smart cities in Canada, a wide range of technologies will be used to implement their initiatives. This section has identified and categorized the key and common technologies used in the initiatives in several key Information and communications technology (ICT) areas including: networking and communications, M2M/IoT, cloud computing, big data and analytics. These areas are interdependent with each other, and therefore the findings reveal that a majority of the Smart City Initiatives uses a technological infrastructure model (chain). To illustrate succinctly the framework one example from each case will be provided.

There will be a number of technologies used across initiatives however, the findings indicate a common technological framework used by three municipalities: Montreal, Guelph/Wellington and Bridgewater. Those municipalities will use use three layers of technological smartness to achieve their goals. The first layer includes the Internet of Things (IoT) technology. IoT is a network of physical connected devices, like vehicles or home appliances, that enable these 'things' to connect and exchange data. IoT devices are used within initiatives for different purposes and in different forms. For example, Town of Bridgewater will use IoT devices such as smart appliances, smart thermostats, and Smart Thermal Optimization to increase energy efficiency ("Bridgewater's Final Application", 2019). Whereas, the City of Guelph/Wellington is using AI-driven sensor-

based technology in their municipal waste collection trucks to gather detailed information about how much residential food waste is going to landfill, what it consists and how much is avoidable (“Guelph/Wellington’s Final application, 2019). This requires a Big Data technology which is a central part of smart city initiatives because the data collected from the smart applications based on IoT needs to be processed and analyzed.

This technological framework will contribute to two realms. First, they improve decision making by offering insights and economic value to the cities and city stakeholders. For example, big data that are collected through the Energy Poverty Reduction Program allow municipal policy makers to make informed decisions based on real-time information, enabling them to further improve energy performance, related energy use, mobility and transportation decisions, etc. Second, these data help in long term planning by ensuring transferability and replicability of the project. As an example, the Data Utility concept developed and generated by Guelph/Wellington can be scaled well beyond its mandate, and as a concept can be replicated in communities across the country. In addition, this project will help multiple communities recognize the value of secure, open collaboration within their local data landscape. Cloud computing will be used by the initiative as a host of remote servers to manage and process huge volumes of data deriving from IoT devices.

Smart city initiative will use and require a reliable, secure and accessible broadband network, a very important element for the Internet of Things and the ability to use big data information to function properly.

Nevertheless, the use of different technologies brings challenges that come with the enormous amount of data generated from public, which raises the issues of security and

rights and responsibilities in the use of personal/public data. Data governance systems require appropriate facilities to govern potentially sensitive and commercially valuable data. Therefore, municipalities need strategies for data governance and to address privacy and security issues.

In addressing this, two main patterns emerge from the winners smart city initiative; creation of data governance framework and compliance with applicable privacy legislation in place.

In all initiatives, the data will be governed by the municipalities. A data governance framework will be created[1]. This framework will address data consent, data sharing opt-out options, server locations etc. Moreover, to address privacy and security issues the four municipalities will take appropriate measures to ensure that their program's data platform and related technologies are in compliance with applicable privacy legislation. Depending on their provincial location, municipalities are subject to regulation including the Personal Information Protection and Electronic Documents Act (PEDA), the Freedom of Information and Protection of Privacy Act (FIPPA), the Municipal Freedom of Information and the Protection of Privacy Act (MFIPPA), and the Personal Health Information Protection Act (PHIPA).

Considering the importance and sensitivity of data protection and security, municipalities will offer training about legal requirements and policies and procedures for organizations (such as local businesses or community agencies) that do not already have an

[1] The municipalities are still working on how this governance framework will look.

established privacy program or for those who are not already subject to legislative requirements under these laws.

4.2 Policy Context

The implementation of technologies is closely linked to the policy context. The political aspects, such as the type of governance and political direction, and the regulatory components such as laws, regulations and intergovernmental agreements, affect the development as well as the implementation of technologies smart city initiatives. This paper has examined the policy context by looking at agents involved in the policymaking process and examining their involvement in the initiative by focusing in the following processes: policy advocacy, resource provisions, policy development and policy implementation. This section has identified common findings throughout the four cities concerning the policy context.

The first emerging trend in the Canadian Smart City Initiatives is the leadership support in the development of the initiatives. The initiatives were proposed by the Office of the Chief Administrative Officer and encountered the leadership support of the Mayor. The mayors of Montreal, Guelph/Wellington and Nunavut were all proponents of the smart city initiative. Interestingly, new elections in October 2018 and the changes in leadership did not affect the support for the initiative. For example, the new mayor of Montreal continued the path of previous administration by prioritizing mobility and even by defining herself as the “Mayor of Mobility” (Picard, 2017).

In addition to Mayoral support and the support within the municipal administrative leadership championing these smart city initiatives, the council's policy directions were a crucial factor for the development and success of these initiatives. The Council meeting minutes in the selected municipalities and the news, show that the councillors from all four municipalities were highly receptive of the initiative demonstrating smart city initiatives high in the priorities of the city councils (Guelph City Council, 2018, July 13, Guelph City Council, 2018, December 12; Goldenberg, 2019; Roth, 2018, Healy, 2018).

Further, the research analysis show that all the initiatives are formed in line with the Strategic plans and are in line with their vision and mission of each respective municipality. This is especially important for the implementation phase because when these plans are aligned with the vision and mission of the organization, the development and implementation of these initiatives becomes less challenging.

Because smart urban solutions can not merely be transplanted from one geographical area to another, smart city ideas must be created locally applicable and meet local needs. Thus, municipality have focused their policy instruments towards harness of the local innovation system. Municipalities have engaged extensively stakeholders of all kinds. Universities, not for profits, consulting firms, businesses are among common stakeholders of the initiatives. The role of stakeholders varies; however, their contribution mainly lies toward providing strategic counsel, subject matter expertise, and project management.

Besides leadership support, knowledge and staff expertise, smart cities initiatives had to comply with the relevant municipal, provincial and federal requirements, legislation and

policies. All the selected initiatives have fulfilled with legal requirements such as privacy concerns, duties to consult and employment benefits.

4.3 Management and Organisation

The complexity of projects requires richness of experiences in implementing the project. The literature has highlighted management and organisation as important success factors or major challenge in the implementation process (Prado et al, 2012). This section will address the various managerial and organizational insights of the initiatives. It will examine the organisational and management structure of initiatives and the organizational challenges these initiatives are facing in achieving its objectives. The organisational and managerial arrangement across the four initiative is different. As such, there are various types of organisational structures identified.

In spite of diverse organisational and intergovernmental settings in all four municipalities, a commonality is the existence of leading committees/office. For example, Montreal's smart city initiative will be led by a governance framework, which consists a hierarchical structure of operational and decision-making committees. These committees have authority to direct and manage the initiative ("Montreal's Final Application", 2019). Similarly, the city of Guelph initiative will be implemented from a formalized Smart City Office (SCO), hosted by the City of Guelph ("Guelph/Wellington's Final application, 2019). Both the cases will have the support from core City and County staff, this approach will help them benefit from existing municipal processes, as well as internal financial, legal, communications and project management capacity. In Nunavut, the proposed governance model and framework is more decentralised based on Inuit societal values

and principles (IQ). The governance model is based on a distributed nature of power across the 25 local level municipalities. Thus, a holistic, multi-level governance model is proposed to ensure that internal structures, functions, processes, rules and relationship behaviours are values and principles-driven and are aligned with the direction, strategy and policies supporting their goals. A new organization called Katinnganiq Makerspace Network (KMN) will be created as the umbrella organization to serve the 25 hamlets involved ("Nunavut Communities Final Application", 2019).

In Bridgewater, a city agency or department will take the lead. For example, the Energy Poverty Reduction Program will be under management of the Chief Administrative Officer (CAO). Final design and implementation of the program lies within responsibility of the Community Development Department ("Bridgewater's Final Application", 2019). The agency/department will play an important role in linking with other related internal and external organizations and stakeholders.

Although the four initiatives have distinct organisational and interdepartmental settings, there are shared features. The findings suggest that initiatives are supported by an open, collaborative governance framework which engages the local community and collaborators as leaders, expert advisors and delivery partners. They will be an integral part of working tables and advisory boards and provide direction, oversight, strategic input and advice.

Evidently, there is no uniform governance model for smart city initiatives among the four cities.

The introduction of IT brings organizational challenges in achieving its objectives. In their applications, the initiatives have made planning for all projects, by identifying potential risks across the project portfolios, and tracing and managing funding allocation and budgets across all projects.

Challenges identified depend on the size of project. Montreal and Guelph mentioned issues with budgets, workforce capacity and infrastructure (un)readiness, as risks that need to be addressed ("Guelph/Wellington's Final Application", 2019; "Montreal's Final Application", 2019). The size of project requires proper and careful allocation of resources. The successful triumph in the Smart City Challenge has addressed for most municipalities the issue of financing. However, the municipalities still need to work in addressing other issues that relate to human resources such as hiring staff and create good, full-time jobs and extensive training in IT for existing staff.

Another challenge relates to the existence of multiple, and sometimes conflicting, goals and agendas. Difficulties in making structural decisions in some committees (disagreement among members) and disparity of the management frameworks of the different partners who will be responsible for certain projects, are among issues listed that need to be address. The municipalities want to overcome these challenges by adopting effective communication plan. These plans will be used to enhance communication and cooperation with stakeholders by sharing information and resources that will help establish clear and realistic goals that aligns interests of parties involved in the initiative.

4.4. Governance

ICTs can enhance policy-making by improving cooperation among stakeholders, including government and citizens

All the initiatives reply on governance models of smart city initiatives that are based on an open, collaborative governance framework, which encourages citizens and stakeholder engagement in the processes. These initiatives are intended to fulfill aspirations of citizens for a more democratic practices and higher involvement in government activities. The use of technology in these initiatives means a contribution in accountability, collaboration (i.e., involving all stakeholders) and participation (i.e., citizens' participation).

In order to empower citizens and stakeholders, and to promote the development of new governance model, ICT-based instruments like social media and open data will be used. For example, the City of Guelph/Wellington will launch a digital governance and engagement platform integrated within social media to promote their initiative and get feedback, facilitating a two-way communication between project teams and the broader community (“Guelph/Wellington Final Application”, 2019). This will enable improved information flow, collaboration, efficiencies and co-production across the governance structure. Montreal will utilize a website and social media as part of its communication strategy. The platform, called “Let’s Talk,” is a interactive platform that explains the concept of Integrated Mobility and keeps the general public informed of upcoming developments or public consultations on the subject (“Montreal’s Final Application”,

2019). Nunavut plans to use social media, specifically Facebook, as an information and outreach tool with their community and stakeholders (“Nunavut’s Final Application, 2019).

4.5 Communities and People

Communities and People will be the main beneficiaries from the smart city initiatives. Smart city initiatives aim to have a direct impact on the citizen’s quality of life and aim to foster more inclusive, educated, and participatory citizens. Three of out four initiative have focus in promoting inclusion and engagement specially for groups who are in need for greater social equity. Both Guelph and Montreal aim to improve the quality of life and the well-being of its citizens through two main pillars: food access and mobility respectively. Similarly, Bridgwater wants to lift its most vulnerable residents out of energy poverty (“Bridgewater’s Final Application, 2019). On the other hand, the Nunavut initiative aims to build resilience, capacity and wellness in their community (“Nunavut Communities Final Application”, 2019). These projects will not only touch the impacted community impact, but also aim to create positive outcomes for the entire community.

The benefits from the initiative are twofold. Knowing those initiatives have a great impact on the quality of their life, people are getting involved in smart city initiatives where they are addressing their demands and wants. This is empowering people with decision-making powers because as mentioned in the management section, citizens are highly involved in planning and implementation process of the smart city initiatives.

4.6 Economy

The economic aspect is one of the outcomes of Smart City Initiatives. There are various types of economic impact resulting from the initiatives, which can be categorised as direct and indirect benefits. Direct economic effects is achieved through (a) direct transportation infrastructure investment, (b) enhanced transit leading to less period in roads, fewer accidents, and a flourishing local trade, (c) adequate power use, including smart lighting and intelligent air conditioning, (d) stronger social facilities such as clinics, colleges, libraries etc., (e) financial incentives for businesses, and (f) efficient regulations for new technologies, such as autonomous electric cars and IoT. Indirect contributions, on the other hand, can be made by (a) improving the overall quality of life, (b) reducing frustration and increasing participation of citizens, (c) encouraging the development of a sense of civil ownership, and (d) building relationships with the private sector (Musa, 2017).

However, the outcomes of the initiatives included in the study will indirectly affect the local economy. The findings show that economic effects will be mainly indirect except for the City of Guelph, which will have a direct impact in the local economy. The City of Guelph/Wellington aims to become Canada's first data- and technology-enabled circular food community by valuing waste as a resource. This will create new opportunities and direct economic impacts such as creation of new businesses, partnerships and jobs. On the other hand, the indirect impact of this project will come to the community from access to affordable and nutritious food. Also, the teaming up of Guelph with Wellington will make the entire region more competitive and attractive within the global context. This will enable the creation of clusters and attraction of talent and the "creative" class, thereby having an indirect contribution to the economy (Florida, 2014).

In Montreal, Bridgewater, and Nunavut, the community will receive economic benefits, but they will be mainly indirect. The benefit from IoT will come improving the overall quality of life and reduce frustration of citizens. In Montreal, the improved public transport and innovative means of transport will save in fuel and time as this aims to shorten the time for commuters stuck in the traffic. On the other hand, the energy efficient technology used in Bridgewater will increase economy access and participation of vulnerable groups.

Nunavut aims to increase the participation of Inuit community in the digital economy. Its computer science curriculum for Indigenous youth in Nunavut — te(a) ch, K12 — will lead to increase participation of Inuit in the digital economy. In Nunavut the context is more complicated. Many of problems derive from deep social and economic issues, and it would be very difficult to fix it immediately, but the initiative at least will be able to leverage technological and informational advantages to spur inclusive economic growth.

4.7 Environment

Environmental protection is another focus of smarter cities initiative. The core concept in the environmental realm is the use of technology to increase the sustainability and to better manage natural resources.

There is a considerable focus on the environmental aspect. All initiatives included in the study will have a direct impact on the sustainability and livability of a city. Three out of four Smart City initiatives are forward looking on the environmental front. This includes Montreal, Guelph/Wellington and Bridgewater. Sustainable transportation alternative, energy conservation and waste management are part of these projects, which will

generate considerable environmental benefits to the communities in these cities. In Montreal, for example, the use of technology will improve efficiency and sustainability of transportation alternatives, whereas in Bridgewater the use of technology will help to save energy (“Bridgewater’s Final Application”, 2019; “Montreal’s Final Application”, 2019). Both these projects will contribute in the reduction of the environmental footprint. In addition, the Guelph project will create a number of climate-related benefits such as reducing transport-related carbon emissions, reducing methane emissions in landfill and increasing resilience to climate change.

In Nunavut, environmental aspects will not be affected as an outcome in their initiative. This also shows that municipalities prioritize the environmental aspect as an issue that have the most significant impact on quality of life.

4.8 Built infrastructure.

Infrastructure can be physical (roads, bridges, buildings, water treatment, waterways) and ICT infrastructures. In the smart city ‘world’, smart Infrastructure is one of the key components’. It is a “result of combining physical infrastructure with digital infrastructure, providing improved information to enable better decision making, faster and cheaper” (Cambridge Centre for Smart Infrastructure and Construction n.d.).

Across the four case studies, there is no impact from the initiative’s in terms of the physical infrastructure. None of the projects anticipates the modernization or advancement of the physical urban infrastructure as a system or service. However, in some cases the aim of initiatives may indirectly result in the improvement of physical infrastructure. For example,

in Bridgewater, the installation of smart power grids as part of the of increasing energy efficiency will result in the improvement of homes, and consequently of physical infrastructure. These infrastructure improvements is monitored by using the connected technology, which feeds in live data. In Montreal, the mobility program favours public shared transit and bicycling and will help to decrease the influx of people and reduce the strain on city roads, bridges, and tunnels. This infrastructure is already struggling to keep up with increases in vehicle distance travelled.

In Nunavut case, physical infrastructure will not be implicated at all.

This shows that municipalities in Canada do not define smartness by modernisation or advancement of physical infrastructure. On the other hand, the technological infrastructure is highly implicated; all four initiatives foresee the development and modernisation of data sharing and data analysis hubs.

Table 3: Main Findings from the Initiatives

Categories	Main Findings
Technology	- Technology is a core component of all initiatives - Key and common technologies used in the initiatives will include: networking and communications, M2M/IoT, cloud computing, big data and analytics. - Data security main issue deriving from the use of technology. - Municipalities have undertaken all the necessary measures by developing processes, protocols, standards that prioritize privacy and safety.
Policy Context	- The support of leadership critically important in the development and implementation of the initiatives. - Implementation of initiatives create a number of legal requirements such as addressing privacy concerns, duties to consult and employment benefits.
Management and Organisation	- The initiatives will be by an organization/office which is common across initiatives. - Interdepartmental and stakeholder collaboration is key in managing smart city initiatives in Canada. - Main organizational challenges derive from the size of project and existence of multiple, and sometimes conflicting, goals and agenda.

Governance	- Citizen-driven innovations and co-creation have been the defining characteristic of much of smart city initiatives - Governance models based on open data available and used effectively in decision-making processes
People and Communities	- Smart city initiatives seen a tool to influence citizens ' quality of life and promotes informed, educated and participatory citizenship - Focus of all initiatives without exception is Inclusion and engagement
Economy	- High focus on sustainable development and circular economy perspective. - Indirect economic contributions made by improving the overall quality of life increasing participation of citizens, and (building relationships with private sectors
Natural Environment	- Environmental quality and protection of the natural environment is highly emphasized throughout the initiatives
Built Infrastructure	- Smartness is defined by Municipalities as modernisation of information and communication infrastructures. Little or no focus on physical infrastructure.

5. Concluding Remarks and Future Research

This main research paper presents the main findings from qualitative analysis of initial and final applications of the four Smart City Challenge winners with the reference to the Smart Cities Initiative Framework provided by literature review.

The research paper has revealed findings, characteristics and challenges of smart city initiatives.

The paper has revealed that technology, management and policy context has been very important in the shaping and formation of the initiatives. Technology is the core component of the initiatives, with IoT technology widely used as a means to achieve goals by enabling better services and a two-way communication network between the citizens and government. It can be considered as the meta factor since it will impact other factors as well.

The transition from a non-smart to a smart city also implies interaction between technological elements and political and institutional elements. Thus, policy context has dictated the implementation of the Initiatives. Municipalities are required to consider and address a good number of municipal and provincial laws and regulations. Furthermore, the particularities of the relationships (intergovernmental relationships) between different levels of governments, presented further opportunities and challenges.

On the other hand, addressing managerial and organizational concerns in smart city initiatives will be very important for municipalities. This includes a wide range of management components such as processes, stakeholders, policies, procedures, resources, societal norms and data exchanging systems that supports the functioning of cities. Thus, municipalities need to implement initiatives responsibly, responsively and transparently which enhances cooperation, information exchange, integration of services and communication.

In terms of outcomes, Smart City Initiatives have prioritized the key issues in city that had the most significant impact on quality of life. Smart city initiatives will influences citizens ' quality of life and promote informed, educated and participatory citizenship. In addition, smart cities initiatives have empowered citizens to engage and become involved in local governance and management. This has also enabled improvement of governance as smart city initiatives require better governance to manage its projects and initiatives.

The research has not compared the smart city initiatives but rather attempted to develop a comprehension of smart city initiatives in Canada and offer new perspectives and lessons that municipalities can learn and share from each other.

This study presents an initial analysis of smart city initiatives and as such represents an exploration research. It has not brought perspectives of actors involved in these initiatives. Therefore, future research can be focused in investigating and observing the actors involved in these initiatives to enrich the debate of what smart city initiatives means and what elements of the smart city are important to Canadian municipalities.

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Appendixes

Table 1 sets out definitions of different literature reviewed articles

Literature	Authors	Definition	Keywords
Academic	Hall et al (2000)	"A city that monitors and integrates conditions of all of its critical infrastructures, including roads, bridges, tunnels, rails, subways, airports, seaports, communications, water, power, even major buildings, can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens"	Infrastructure monitoring, Integrate critical infrastructure, resource optimization, preventive maintains, monitor security, maximizes services
Academic	Giffinger et al (2007)	"A city well performing in a forward-looking way in economy, people, governance, mobility, environment, and living, built on the smart combination of endowments and activities of self-decisive, independent and aware citizens."	Economy, people, governance, mobility, environment, quality of living
Academic	Harrison et al (2010)	A city "connecting the physical infrastructure, the IT infrastructure, the social infrastructure, and the business infrastructure to leverage the collective intelligence of the city"	physical infrastructure, the IT infrastructure, the social infrastructure, and the business infrastructure
Academic	Washburn et al (2010)	"the use of smart computing technologies to make the critical infrastructure components and services of a city—which include city administration, education, healthcare, public safety, real estate, transportation, and utilities—more intelligent, interconnected, and efficient	Smart Computing, Services and Critical infrastructure, city administration, education, healthcare, public safety,

			real estate, transportation
Academic	Nijkamp et al	A city to be smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance	Investment, Human Capital, Social Capital, Transportation, Information and Communication Technology, sustainable economic growth,
Academic	Mohanty et al (2016)	"A smart city is a place where traditional networks and services are made more flexible, efficient, and sustainable with the use of information, digital and telecommunication technologies, to improve its operations for the benefit of its inhabitants. In other words, in a smart city, the digital technologies translate into better public services for inhabitants, and for better use of resources while impacting the environment less"	Traditional networks, services, flexible, sustainable, information, digital technologies,
Academic	IBM (2010)	Smart city is defined by IBM as the use of information and communication technology to sense, analyze and integrate the key information of core systems in running cities	Information technology, communication, information integrations, core systems

Government	European Innovation Partnership on Smart Cities and Communities	Smart cities should be regarded as systems of people interacting with and using flows of energy, materials, services and finance to catalyse sustainable economic development, resilience, and high quality of life; these flows and interactions become smart through making strategic use of information and communication infrastructure and services in a process of transparent urban planning and management that is responsive to the social and economic needs of society.	Information System Technologies, urban planning, finance, sustainable, economic, resilience, quality of life,